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# Determination of somatotypes of children with adolescent idiopathic scoliosis and its relationship with scoliosis

Adolescents with idiopathic scoliosis have lesser endomorphic somatotype

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**Abstract**
Aim: Adolescent idiopathic scoliosis (AIS) is a three-dimensional deformity of the spine. In adolescence, body morphology can change for various reasons such as genetics, nutrition, and level of physical activity. It has been reported that there are differences in the normal physical growth pattern in children with AIS, which may be due to hormonal changes. The relationship between body morphology and scoliosis is questionable because of the differences that scoliosis creates in the spinal structure. The aim of this study was to define the somatotype characteristics of children with AIS and compare the somatotypes with healthy, age and sex-matched controls.
Material and Methods: A retrospective evaluation was performed on 38 children with AIS and 27 age-matched healthy control subjects. Cobb angles and angle of trunk rotation (ATR) values were used to determine scoliosis and trunk gibbosity. Cobb angles were measured on standing anterior-posterior radiographs and the ATR using Adam's forward bending test with a scoliometer. Somatotypes were defined according to the Heath-Carter method and body morphology was categorized into three different components: endomorphy, mesomorphy, and ectomorphy.
Results: Ectomorphy was the dominant type in the AIS group, and endomorphy was the dominant type in the control group. The endomorphic somatotype in individuals with scoliosis was determined at a statistically significantly lower rate than in the control group (p=0.048). There was a moderate negative correlation (p=0.001, r=-0.466) between the Cobb angle and the values of the endomorphy component, and between the ATR and the endomorphy values (p=0.010, r=-0.318).
Discussion: The lower rate of endomorphic somatotype was an evident difference in children with scoliosis. These differences may cause problems in the growth and development of the spine and the skeletal structures attached to the spine during adolescence when rapid growth and development occur. Whether this difference is related to nutrition, genetic and hormonal factors, or psychosocial factors remains to be determined.

**Keywords**
Somatotype, Scoliosis, Adolescents, Human Body Morphology

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## Introduction

Adolescent Idiopathic Scoliosis (AIS) is a structural deformity that affects the spine and trunk during the growth period. According to the Cobb method, lateral curvatures of 10 degrees or more in the spine are defined as scoliosis. Curvatures measured below 10 degrees are considered physiological spinal asymmetry [1,2]. Although the magnitude of scoliosis is defined only according to the Cobb angle and the type of curvature in the frontal plane, it is a three-dimensional deformity characterized by sagittal plane changes and rotation in the transverse plane [1,2]. Some neurological diseases and musculoskeletal problems are known to have a role in the etiology, but in 80% of cases, it is defined as idiopathic [3]. AIS and scoliosis caused by underlying neuro-musculoskeletal diseases are orthopedic disorders of the developmental period usually seen during growth and development [4]. Adolescence is a period of rapid growth and development, and the physical maturation of the body. During this period, somatotype changes may occur depending on various factors such as genetic characteristics, nutrition, physical activity habits, and sporting activities [5,6].

Somatotype is a classification system that morphologically categorizes the human body into three different components: endomorphy (relative obesity), mesomorphy (relative musculoskeletal development) and ectomorphy (relative linearity) [6,7]. Endomorphy is characterized by the predominance of the digestive organs, and soft and rounded body contours. Low endomorphy indicates a weak physique with minimal subcutaneous fat, whereas high endomorphy values are indicative of obesity. Mesomorphy is characterized by the dominance of muscle, bone and connective tissue and sharply delineated muscles. Low mesomorphy is an indication of narrow bone diameter and low muscle weight compared to physical structure. High mesomorphy is indicative of large bone diameter and high muscle weight. An example of this body structure is an elite bodybuilder. Ectomorphy is characterized by a linear and fragile structure with limited muscle development. While low ectomorphy means more weight compared to the structure, high ectomorphy values are indicative of low weight relative to the build and relatively long limbs. Ectomorphy values correlate with endomorphy and mesomorphy values. For example, low ectomorphy values are associated with increased endomorphy and/or mesomorphy values [8, 9].

The relationship between body morphology and scoliosis is questioned because of the differences that scoliosis creates in the spinal structure. Since the 1990s, the relationship between scoliosis and body morphology has been studied in different societies and it has been suggested that children with AIS may have some anthropometric differences compared to healthy children [10,11]. It has been reported that there are differences in the normal physical growth pattern in children with AIS, which may be due to hormonal changes [12-14]. Some studies have reported that eating disorders are related to low body weight and BMI in adolescents due to the stress caused by deformity [12,14]. The results of studies examining the somatotypes of individuals with AIS are contradictory. Some studies have reported that individuals with AIS are taller than healthy control subjects [15,16], while others have reported that they are shorter in stature [14,17]. In a study with 905 participants, it was reported that girls with AIS were significantly shorter than healthy control subjects before puberty began, and taller than healthy control subjects after puberty [13].

To the best of our knowledge, there is no study in the Turkish population examining the body morphology of children diagnosed with AIS. The identification of structural differences associated with growth and development in individuals with scoliosis may lead to new targets and strategies for the treatment of AIS to be able to prevent progression or reduce the risks of this growth and developmental problem.

The aim of this study was to define the somatotype characteristics of children with AIS and to compare these with the somatotypes of healthy control subjects with similar age and gender characteristics.

## Material and Methods

This retrospective controlled cohort study included data obtained from the evaluation of healthy adolescents with idiopathic scoliosis who presented at Silivri Municipality, Disabled and Elderly Coordination Center between 2011 and 2021. All identifying information was removed so that all the data included in the study were analyzed anonymously using computer software. The research was carried out in accordance with the Declaration of Helsinki, and with the approval of the Ethics Committee of Istanbul Kultur University (Date: 2022-04-25, No: 2022/86).

The study inclusion criteria were defined as being a healthy adolescent between the ages of 10-19 years, and diagnosed with AIS by a specialist physician. Exclusion criteria were defined as any mental, neurological, rheumatological, or orthopedic problem, the presence of a congenital or acquired orthopedic problem other than scoliosis in individuals diagnosed with AIS, any diagnosis that may cause growth and developmental retardation, receiving growth hormone treatment, having undergone surgical treatment for AIS, or a history of injury that would affect posture.

Demographic characteristics such as age, gender, weight, height, anthropometric measurement results, and Cobb angles and ATR (Angle of Trunk Rotation) angles of the adolescents diagnosed with AIS were obtained from the evaluation records recorded for each patient. Height was measured using a wall-mounted Mesilife, Q100 height meter, and body weight using scales sensitive to 0.1 kg (Charder®).

Cobb angles were measured on standing anterior-posterior whole spine X-ray images of adolescents diagnosed with idiopathic scoliosis by a specialist physician, and in patients with more than one curvature, the highest measured Cobb angle value was included for analysis. The trunk rotation angles of all the participants were measured with the Bunnell scoliometer in Adam's forward bending test, and the largest trunk rotation angle values were included for analysis.

The somatotypes of the adolescents were determined according to the Heath-Carter method, with the dominant shoulder at 90° flexion, 45° elbow flexion, and the fist clenched. Using a flexible tape measure from the widest part of the arm, arm circumference and dominant side, leg circumference were measured. Triceps, subscapular, supraspinal subcutaneous fat from the widest part of the calf, and medial calf subcutaneous fat measurements were taken with knees flexed at approximately 90° while sitting, with a Holtain skinfold caliper. The elbow joint diameter at 90° flexion while standing, and knee joint diameter at 90° flexion while sitting were measured with a Holtain bicondylar caliper. All these recorded anthropometric parameters were imported into calculator program for the calculation of somatotypes using the Heath-Carter method [21].

The data obtained in the study were analyzed statistically using the SPSS vn. 16 software (Statistical Package for Social Sciences Inc., Chicago, IL, USA). The normality of the data was assessed with the Kolmogrov-Smirnov test. The distribution of gender and body somatotype classifications of the groups was analyzed with the Chi-square test. The Independent Samples t-test was used to compare the height, weight and BMI average values of the groups, and mesomorphy and ectomorph body somatotype measurement values. The Mann-Whitney U-test was used to compare the age and endomorphy somatotype values. The distribution of somatotype classifications according to Cobb angle and age was analyzed with the Chi-square test. The relationship between related parameters was also analyzed using Pearson's correlation coefficient test. A value of $p<0.05$ was accepted as statistically significant in all the analyses. Power analysis showed that the number of participants (43) included was above the minimum sample size required to ensure a power of 95% confidence level and to detect statistical significance at a two-sided significance level of 0.05.

*Ethical Approval*

Ethics Committee approval for the study was obtained.

## Results

The study included a total of 65 participants, including 38 children diagnosed with AIS and 27 healthy control subjects in a similar age group without scoliosis.

The study included 60 (92.3%) females and 5 (7.7%) males. The gender distribution, age, height, weight and body mass index values of the participants in both groups were similar (Table 1). When the somatotype data were compared, it was determined that ectomorphy was the dominant type and mesomorphy was the predominant type in the AIS group (respectively: Endomorphy; 2.3 – Mesomorphy; 2.8 – Ectomorphy; 3), while endomorphy was the dominant type in the control group, and ectomorphy was the predominant type (Table 1). The endomorphy value in the AIS group was found to be statistically significantly lower than in the control group ($p<0.001$).

When the dominant somatotypes of the groups were evaluated with the Chi-square test, there were determined to be significantly fewer endomorphic types in the group with scoliosis. The endomorphic somatotype in individuals with scoliosis was statistically significantly lower than in the control group (p= 0.048). The somatotypes of the groups are shown in Figure 1.

The AIS group was separated into two sub-groups: mild scoliosis (Cobb angle 10°-19°) and moderate scoliosis (Cobb angle >20°) according to the intensity of the curvature, and the somatotypes were then analyzed. The mild scoliosis group included 10 patients (mean Cobb: 12.8 ± 2.6), and the moderate and high grade (30 ± 10.1) scoliosis group included 28 patients. The curvature pattern was determined as right thoracic, left lumbar in 27 patients, thoracolumbar in 6, lumbar in 4, and left thoracic, right lumbar in 1. A Cobb angle of ≥ 40° was determined in 5 patients and these were included in the moderately severe scoliosis group. When the somatotype values were compared between the mild and moderate scoliosis groups according to the severity of the scoliosis angle, there was no significant difference between the groups (p= 0.101), however, the number of participants with endomorphic body type was lower in both groups.

**Table 1.** Participants' demographic characteristics, somatotypes and differences in scoliosis data between AIS and Control groups.

| | AIS N=38 | Control N=27 | p-value |
|---|---|---|---|
| | Frequency (n%) | Frequency (n%) | |
| Gender | 36 Females (94.7%) | 24 Females (88.9%) | 0.383* |
| | 2 Males (5.3%) | 3 Males (11.1%) | |
| | Mean ± SD<br>Median (min - max) | Mean ± SD<br>Median (min - max) | |
| Age (year) | 13.5 ± 1.8 (10 - 16) | 13.4 ± 1.1(10 - 16) | 0.920 |
| Height (cm) | 157.1 ± 10.4 (130 - 176) | 154.2 ± 9.2 (132 – 173.3) | 0.309 |
| Weight (kg) | 48.8 ± 11.7 (24 - 74) | 48.6 ± 9.5 (32 - 65) | 0.953 |
| BMI (kg/m²) | 19.5 ± 3.5 (13.4 - 29.2) | 20.3 ± 3.4 (15.1 - 29) | 0.399 |
| Height/Weight Ratio (cm/kg) | 43.3 ± 2.3 (38.8 - 47.6) | 42.5 ± 2.4 (36.8 - 46.3) | 0.204 |
| Endomorphy | 2.3±0.9 (0.9 – 5.2) | 4.1±1.8 (1.6 – 8.4) | <0.001 |
| Mesomorphy | 2.8±1.4 (0.1 – 6.3) | 2.8±1.5 (0.1-5.3) | 0.202 |
| Ectomorphy | 3±1.6 (0.1- 6.3) | 3.3±1.4 (0.1 – 7.5) | 0.343 |
| Max.Cobb angle (°) | 25.4 ± 11.6 (10 - 60) | - | - |
| Max.ATR (°) | 7.8 ± 3.8 (2 - 18) | 2.4 ± 2.1 (0-7) | 0.001 |

AIS: Adolescent Idiopathic Scoliosis, ATR: Angle of Rotation, BMI: Body Mass Index.

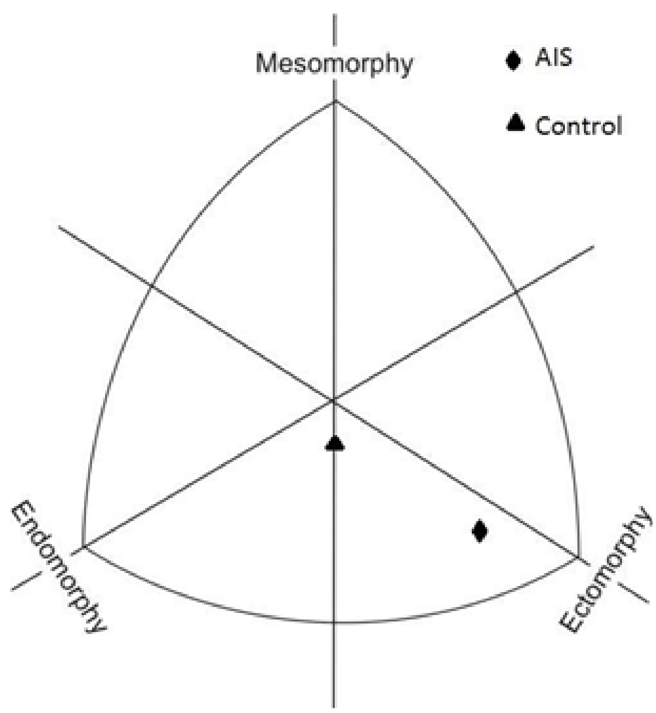


**Figure 1.** View of somatotypes between AIS and control groups in somatochart.

**Table 2.** Somatotype characteristics by age groups.

| | AIS (n=38) | | Control (n=27) | |
|---|---|---|---|---|
| | Under 14 years old (n=20) | 14 years and older (n=18) | Under 14 years old (n=17) | 14 years and older (n=10) |
| Endomorphy Frequency (n%) | 5 (25%) | - | 9 (52.9%) | 5 (50%) |
| Mesomorphy Frequency (n%) | 8 (40%) | 9 (50%) | 8 (47.1%) | 3 (30%) |
| Ectomorphy Frequency (n%) | 7 (35%) | 9 (50%) | - | 2 (20%) |
| p-value | 0.074 | | 0.145 | |

AIS: Adolescent Idiopathic Scoliosis

There was a moderate negative correlation between the Cobb angle and the values of the endomorphy component (p= 0.001, r= -0.466) and a moderate negative correlation between the trunk rotation angle and the endomorphy values (p= 0.010, r= -0.318).

The participants in both groups were aged 10-16 years. Two sub-groups were formed as <14 years and ≥14 years, and the dominant somatotype distributions of the children were compared with the Chi-square test (Table 2). A statistically significant difference was determined between the groups (p= 0.019). When the dominant somatotypes of children aged ≥14 years were compared, a statistically significant difference was observed between the AIS and control groups (p= 0.014). There were no children <14 years of age with somatotype-dominant ectomorphic features in the AIS group, while endomorphy-dominant children aged ≥14 years were present in the control group.

## Discussion

The results of this study demonstrated a significantly lower endomorphic somatotype of adolescents with idiopathic scoliosis compared to healthy control subjects. The endomorphy values associated with the body fat ratio were determined to be lower in the AIS group. The ectomorphic somatotype was more dominant in scoliosis patients with a Cobb angle of >20°, and the mesomorphic somatotype was dominant in children with a Cobb angle of ≤19°.

Throughout history, researchers have investigated the physical structure of the body in different ways. Hippocrates was the first to introduce concepts related to body structure [8]. The three-component body configuration classification method defined by William Sheldon as endomorphy, mesomorphy and ectomorphy, is still widely used today for the evaluation of body structure [8, 9]. It is accepted that this theoretical approach is based on the hypothesis that there is a continuous change in body structure distribution and that this change is associated with different contributions of three specific components that characterize body configuration.

During growth and development, there are significant changes in the size, structure, proportion and composition of the body. It has been shown that somatotype changes occur depending on age and cultural characteristics [19-22]. Girls are more endomorphic and less ectomorphic than boys. The mesomorphic component tends to decrease in girls during adolescence, whereas in boys, the mesomorphic component continues to be more dominant. Both males and females tend to have higher endomorphism with increasing age, although this trend occurs earlier in adolescent girls [19,22]. It has been reported that individuals with endomorphic somatotypes mature early and ecto-mesomorphic individuals have delayed maturation [23]. In a more recent study, it was revealed that the susceptibility to the endomorphic component increased in both genders for all age groups over the years [24].

Although there are studies investigating the relationship between adolescent idiopathic scoliosis and somatotype, these are limited in number. The first studies investigating somatotype in adolescent idiopathic scoliosis were conducted with the hypothesis that body type has an effect on determining the risk of progression [10,11]. LeBlanc (1997,1998) suggested that it may be possible to distinguish healthy adolescents, adolescents with non-progressive scoliosis, and adolescents with progressive scoliosis by somatotype classification [10,11]. The same researchers also thought that early diagnosis of AIS would be possible with somatotype assessment [10,11] and reported that girls with AIS had problems in the development of bone and muscle structure and were less mesomorphic [10]. Unlike the work of LeBlanc (1997, 1998), Barrios (2017) reported that girls with scoliosis were higher ectomorphic and lower mesomorphic than healthy control subjects. It was stated that the most important difference in the somatotype of girls with scoliosis was not the predominant endomorphic component associated with the fat ratio [14].

Cheung (2003) reported that abnormal growth and development in girls with scoliosis are usually observed at the age of 12-15 years and older [13]. Girls diagnosed with AIS were found to be shorter before puberty than the control group, and taller after the onset of puberty, with lower weight and BMI values compared to the control group during the peri-pubertal growth period [13]. Smith (2002) reported that children diagnosed with AIS with a mean age of 16 years had a lower body weight and BMI, which could indicate an eating disorder, compared to a control group [12]. The results of the current study, in parallel with the literature, showed that the endomorphy component was lower in children with AIS.

LeBlanc (1997) reported that children diagnosed with AIS with a mean age of 14 years and a Cobb angle of 10°-19° have more pronounced muscle and bone development than children with a Cobb angle of ≥20° [10]. In another study (Smith 2002), it was reported that BMI, which is an indicator of body adiposity during the rapid pubertal growth period, was significantly lower in children with AIS [12]. Those authors also reported a weak correlation between the severity of the Cobb angle and body weight and BMI values. [12] In the current study, a weak to moderate correlation was found between the severity of the Cobb angle and ATR and the endomorphic component.

Normalli (1985) reported that girls with idiopathic scoliosis had a later menarche than the control group and were taller during menarche [17]. Similarly, in another study (Weiss HR et al. 2015), it was determined that girls with AIS had a later menarche, were shorter at the age of 12 years, but reached the height of the control group at age 14 – 16 years. Around the age of 14 years, girls usually reach the Risser 3 stage, and the growth potential and the risk of curvature progression decrease [4]. In the current study, when the somatotype characteristics of the children were examined in the age groups of <14 years and ≥ 14 years, it was determined that the predominance of endomorphy was significantly less in children diagnosed with AIS aged over 14 years. In the children included in this study, the age of menarche and bone development levels such as Risser or Sanders were not evaluated. Due to the insufficient number of cases, somatotype characteristics could not be examined according to curvature patterns. It can be suggested that in future studies a more detailed somatotype evaluation should be made by evaluating physical activity characteristics in children with different curvature patterns and curvature severity. It would also be beneficial to examine whether different treatment methods influence the body somatotype of children with AIS.

## *Conclusion*

The number of studies examining body morphology in individuals with adolescent idiopathic scoliosis is quite limited. When compared with healthy individuals in the same age group, it can be seen that there is a difference in the somatotypes of adolescents with idiopathic scoliosis. These differences may cause problems in the growth and development of the spine and the skeletal structures attached to the spine during adolescence, when rapid growth and development occur. Endomorphy values were seen to be low in children with AIS, indicating that the body fat ratio is low. There is a need for further studies with longer follow-up periods to determine whether this situation is caused by nutrition, genetic and hormonal factors, or psychosocial factors as a result of the scoliosis treatment.

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***Scientific Responsibility Statement***
*The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.*

***Animal and human rights statement***
*All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.*

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